United States Patent [19]

Best

[11] **3,777,694**

[45] **Dec. 11, 1973**

[54] **AUTOMATIC DEVICE FOR TRIMMING VESSELS**

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[73] Assignee: **A. M. and I. Levellers Ltd.**, Vancouver, British Columbia, Canada

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[21] Appl. No.: **271,232**

Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 067,479, Aug. 27, 1970, abandoned.

[52] **U.S. Cl.** .... **114/126**, 114/122, 250/219 DD, 250/231 SE, 318/489, 318/588, 318/640, 318/648

[51] **Int. Cl.** **B63b 39/00**

[58] **Field of Search** .... 33/302, 304, 306, 33/312–313, 366, 395; 114/122, 126; 244/15 A, 3.21, 77 D, 77 F; 250/217 R, 219 DD, 231 SE; 318/584, 586, 588, 489, 640, 648

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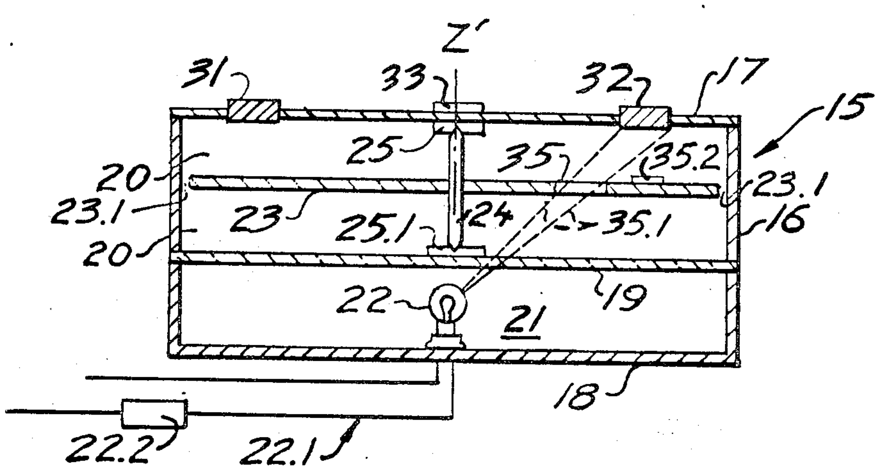
[57] **ABSTRACT**

An automatic device for trimming vessels is disclosed having a sensing device responsive to continued departure from a desired attitude (e.g. list), trim tabs adapted to correct such departure, and electro-mechanical apparatus interconnecting the sensing device and trim tabs. The sensing device has an unbalanced pivoted disc with an opening. When the vessel lists the disc rotates with the opening becoming aligned between a photocell and a light source. The photocell output is then amplified and utilized to close a relay energizing an electric motor to opeate the trim tabs. The sensing device includes fore, aft, port and starboard photocells each associated with an amplifier and a relay circuit in the electro-mechanical interconnection apparatus.

13 Claims, 4 Drawing Figures



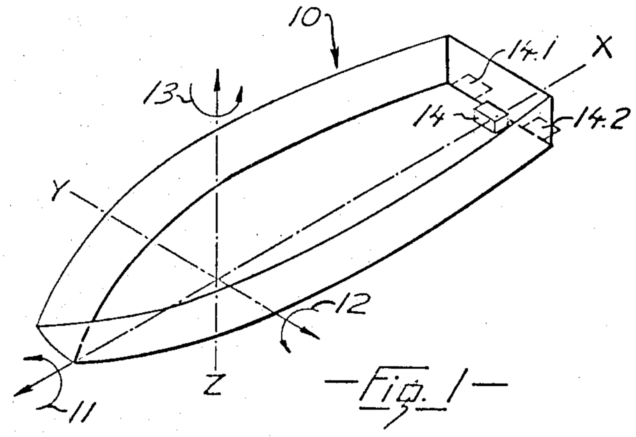

10
13
14.1
X
14
14.2
Y
12
Z
11

Fig. 1

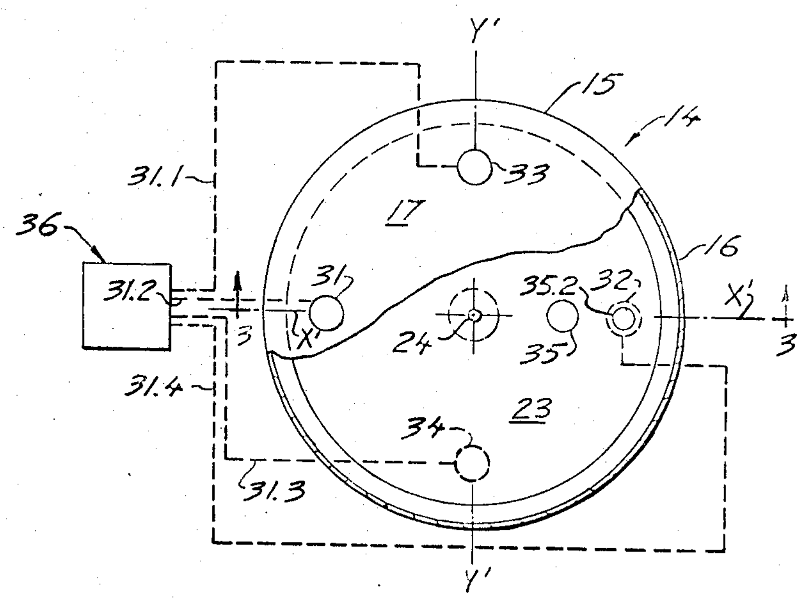
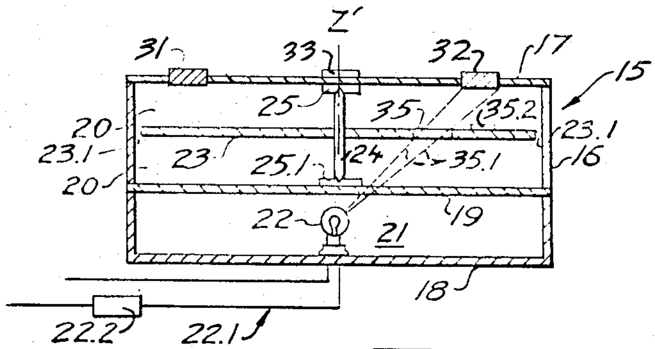
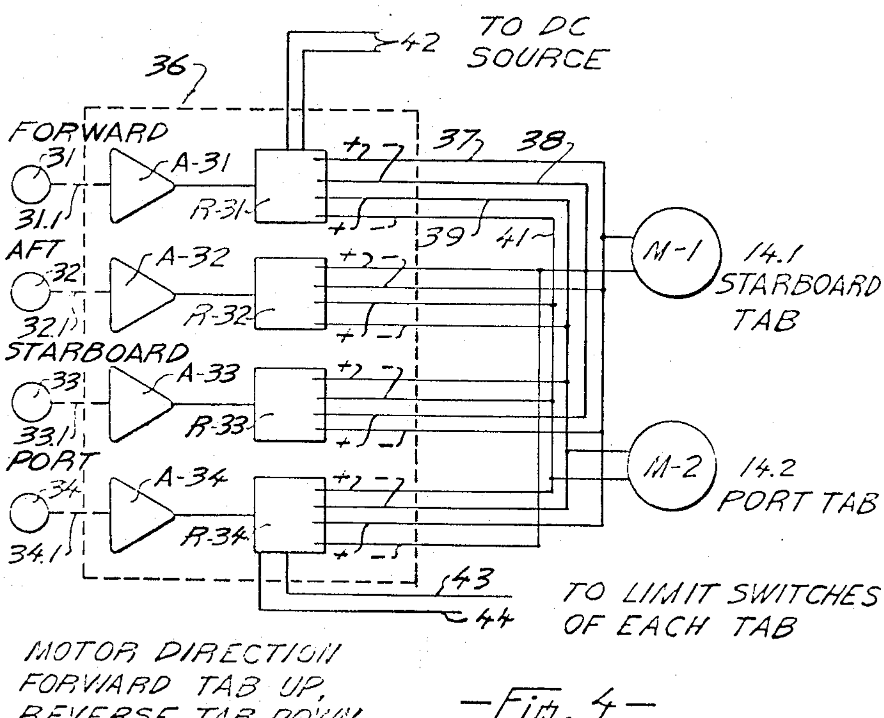

Y'
15
14
31.1
33
17
36
16
31.2
31
35.2
32
X'
3
X'
24
35
3
31.4
23
34
31.3
Y'

Fig 2


Z'
31
33
32
17
15
25
35
35.2
20
23.1
23.1
23
25.1
24
35.1
16
20
19
22
21
18
22.2
22.1

—Fig. 3—


TO DC SOURCE
42
36
37
38
FORWARD
31
A-31
R-31
31.1
39
41
AFT
32
A-32
R-32
32.1
M-1
14.1
STARBOARD TAB
STARBOARD
33
A-33
R-33
33.1
PORT
34
A-34
R-34
34.1
M-2
14.2
PORT TAB
43
44
TO LIMIT SWITCHES OF EACH TAB
MOTOR DIRECTION
FORWARD TAB UP,
REVERSE TAB DOWN

—Fig. 4—

AUTOMATIC DEVICE FOR TRIMMING VESSELS

CROSS-REFERENCE TO RELATED APPLICATIONS

This is a continuation-in-part application of my co-pending application Ser. No. 067,479 filed Aug. 27, 1970. now abandoned.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The invention relates to an automatic device used for trimming ships.

2. Prior Art

Ships, particularly small and medium size vessels, are sensitive to unbalanced loading or movement of cargo or passengers. Unbalanced conditions can result in an undesirable attitude of the vessel such as a stern up trim which causes an excessive bow wave, or a stern down trim that produces an excessive wake. This results in ineffective use of motive power or an unpleasant ride or both. List from such causes is also undesirable.

In a small vessel, an undesirable attitude as above is commonly corrected by a steersman manually adjusting a trimming means, e.g., variable incidence trim tabs at the stern of the vessel. Alternatively ballast or cargo can be shifted to correct the unbalanced condition. Sometimes such correction is adequate — but with a mobile cargo such as a heavy catch of fish in a hold, or passengers moving about on board, continuous manual correction by either means above is impractical.

For optimum performance at design cruise speed, a predetermined attitude, hereinafter design attitude, is maintained. Maintaining the design attitude is referred to herein as trimming, and is distinguished from stabilizing which, broadly, is damping periodic motions resulting, e.g., from wave action.

U.S. Pat. No. 3,169,501 issued to Wesner in 1965 teaches linear and angular accelerometer and rate gyro means for list compensation in a ship stabilization system, producing a composite signal to activate a servo amplifier and mechanical ancillaries. The present invention teaches simple electronic and electro-mechanical means to compensate for unbalance as defined above.

SUMMARY OF THE INVENTION

An automatic trimming device according to the present invention is directed to compensate and correct improper trim of a moving vessel. The device includes a sensing means responsive to continued departure from design attitude, a trimming means adapted to correct the continued departure, and means interconnecting the sensing means and the trimming means adapted to activate the latter to correct the departure aforesaid.

The vessel has mutually perpendicular X and Y axes of roll and pitch respectively defining a horizontal plane when the vessel is in the design attitude, and a mutually perpendicular Z axis. The sensing means includes an unbalanced disc mounted for free rotation about a pivot axis parallel to the Z axis. The disc has an opening and rotates in a closed chamber containing a damping fluid which has sufficient viscosity to reduce speed of response of the disc to filter short period oscillations arising from wave motion. Forward and aft photoelectric cells lie in a plane normal to the Y axis, and port and starboard photoelectric cells lie in a plane normal to the X axis - these planes intersect in the pivot axis. A light source is provided, rays from the light source impinge one particular photocell when the opening is in a plane containing that photocell and the pivot axis thus energizing the photocell.

Unbalance of the disc is effected by a small unbalancing weight say about an ounce, radially aligned with the opening. With for instance a port list the port photocell is thus impinged by rays from the light source. Amplified output of the photocell operates a relay closing a power circuit to an electric motor which activates a trim tab adapted to correct the list.

A detailed description following, related to drawings, gives exemplification of preferred embodiment of the invention which however, is capable of expression in structure other than that particularly described and illustrated.

DESCRIPTION OF THE DRAWINGS

FIG. **1** is a perspective diagram showing axes of a vessel and trimming means,

FIG. **2** is a top plan view of a sensing means according to the invention, parts being broken away to show internal structure,

FIG. **3** is a fragmented section on **3—3** of FIG. **2** some parts not being shown in section,

FIG. **4** is a block diagram showing electric motor control means.

DETAILED DESCRIPTION

General Description of the Invention Related to FIG. 1.

A vessel **10** has cardan axes X, Y, Z, the axes X and Y being in a plane, hereinafter the X-Y plane which is horizontal in the design attitude, design attitude being as previously defined. Rotation about the X axis is rolling, about the Y axis is pitching, and about the Z axis is yawing, design attitude being independent of yaw. Rolling pitching and yawing rotations are designated respectively by arrows **11, 12, 13.** Oscillatory motions about the X and Y axes occur continually from, for instance, wave motion. These motions are periodic and can be damped by known means, which damping is referred to as stabilization. Unbalanced loading can cause, for example, list in a direction indicated by the arrow **11.** If not corrected, the list remains at constant magnitude, the periodic motions of rolling being superimposed upon the list. The unbalanced load can be such as to cause stern up trim, being rotation through an angle in a direction indicated by the arrow **12.** The angle, or pitch, remains constant so long as the unbalanced loading continues, and periodic pitching from, for instance, wave motion, is superimposed. Stabilization damps pitching and rolling which as aforesaid are periodic oscillations. The present invention is directed to correcting list and stern up or stern down attitude (constant pitch) and does not effect stabilization. The invention has no direct effect upon yawing, ordinarily corrected by a rudder.

A sensing means according to the invention is designated **14** and is operatively connected to transom mounted stern trimming tabs by means later explained. The trimming tabs are of a known kind and are individually rotatable about axes parallel to the Y axis so that, when the ship is at speed, port or starboard list, or stern up and stern down attitude, can be corrected. The present invention provides sensing means to activate the trim tabs automatically providing tab motions later explained in detail.

Description of FIGS. 2 and 3.

The sensing means **14** has a sealed housing **15** with a cylindrical side wall **16** and spaced circular top and bottom end walls **17** and **18.** A transparent partition **19** divides the housing forming an upper chamber **20** and a lower chamber **21.** A light source **22** is mounted within the lower chamber **21** central of the bottom wall **18.** The light source is energized from an electrical power supply, not shown, through lines **22.1,** a flasher **22.2** being provided so as to produce intermittent light pulses. As is later explained, it is convenient that the flasher be adjustable so that repetition rate and/or pulse duration parameters can be varied. The rate can be such that a pulse occurs at intervals of between about one and about five seconds, pulse duration being typically from about a quarter to about a half of a second. An opaque disc **23** is secured on a pivot shaft **24,** the shaft being mounted in pivot bearings **25** and **25.1** of the top wall **17** and of the partition **19** as shown. The disc is freely rotatable, and has a diameter such as to provide a clearance as indicated at **23.1** FIG. **3** so that there is not material light leakage past the disc through the clearance.

The transparent partition **19** provides a convenient means to mount the pivot bearing **25.1,** alternatively this bearing can be mounted atop of a tripod (not shown) secured to the bottom wall **18** — with legs of the tripod straddling the light source **22** clear of rays therefrom. The partition is not then required.

The sensing means has axes X′ and Y′ seen in FIG. **2,** these axes being at right angles and in a plane parallel to the X-Y plane FIG. **1**; and an axis Z′ FIG. **3** parallel to the Z axis FIG. **1,** the pivot shaft **24** having a central axis coincident with the Z′ axis. The housing top wall **17** has four openings, a photoelectric cell being mounted in each opening. Forward and aft photoelectric cells **31** and **32** FIG. **3** are on X′ axis, and starboard and port photoelectric cells **33** and **34** are on the Y′ axis, the cells having centres equidistant from the Z′ axis. The cells **31–35** are B-832001 LSR photovoltaic cells, hereinafter photocells. The opaque disc **23** has an opening **35** which, as seen in FIG. **3**, is aligned between the photocells and the light source **22** so that, during a light pulse, rays **35.1** from the light source impinge the aft photocell **32** when the opening is in a plane containing the X′ and Z′ axes, and is aft of the Z′ axis as shown in FIG. **3.** Similarly, rays from the light source impinge upon a photocell **31,33,** or **34,** when the disc is rotated so that the opening **35** is correspondingly aligned with one of the photocells **31, 33** or **34.**

Relative positions of the photocells, the light source **22,** and the opening **35** of the unbalanced disc, are defined as follows. The forward and aft photocells are in a plane normal to the Y axis, the port and starboard photocells are in a plane normal to the X axis, these planes intersecting in the pivot axis. Rays from the light source impinge a particular photocell when the opening is in a plane containing that particular photocell and the pivot axis.

The opaque disc **23** has a weight **35.2** mounted in radial alignment with the opening **35,** and is hereinafter referred to as an unbalanced disc. Were the Z′ axis truly vertical with zero angular and linear accelerations of the vessel the disc would be in neutral equilibrium. With a stern down attitude the unbalanced disc rotates to the position shown in FIG. **3** so that pulse rays from the light source impinge the photocell **32.** With a stern up bow down attitude, the unbalanced disc rotates to assume a position at which the pulse rays impinge the photocell **31** with a list to port rays impinge the port photocell **34** and with a starboard list photocell **33** is impinged.

A vessel at rest is not in the design attitude being typically 3° or 4° bow down relative thereto. Consequently in installing the sensing means when the vessel is at rest in calm water, the Y′ axis is set to be horizontal and the X′ axis is set to the 3° or 4° off horizontal so that, in the design attitude the X′ axis becomes horizontal.

As previously stated, the sensing means is adapted to detect list, that is a generally non-periodic motion which is distinguished from periodic motions, for instance short period oscillations resulting from wave motion. For effective operation of the sensing means, the effects of short period oscillations as above are reduced so that the device responds only to long term non-periodic tendencies. The short period oscillations can be effectively filtered by damping relatively lively oscillations of the disc. Damping is most easily effected by filling the upper chamber **20** with a damping fluid, which fluid has a particular viscosity and other characteristics dependent on the characteristics and use of the vessel. The damping fluid has sufficient viscosity to reduce speed of response of the disc to filter short period oscillations. With sufficient damping, the disc does not oscillate excessively and a tendency of the disc to actuate a photocell on one side of the chamber and immediately thereafter actuate a photocell on an opposite side is reduced.

One example of damping fluid includes a mixture of two constituents, namely commercially pure kerosene and glycerine, ratio of the two constituents being varied to suit the application and size of the vessel and also the method of trimming. For a twenty-eight foot, hard-chine hull fitted with an inboard/outboard sterndrive unit the ratio of the constituents was found to be between one and three percent of glycerine, the balance being kerosene. For a longer vessel, with an inherently slower responce to wave motion a damping fluid of lower viscosity would be suitable. For a shorter vessel having a quicker response to wave motion a damping fluid of higher viscosity would likely be suitable. Adjustment of repetition rate and/or pulse duration also effects response of the sensing means, permitting fine adjustment to suit vessel characteristics.

Other damping fluids can be used, but care must be taken in selection so that the fluid does not react with the materials of the housing, or gaskets associated therewith, the gaskets not being shown. The fluid is essentially transparent for a normal working life under normal temperature and humidity, thus maintaining essentially constant light transmission through the disc. Because the disc rotates in the pivot bearings **25** and **25.1** carrying the pivot shaft **24,** the damping fluid is selected so as to have negligible effects on the friction associated with the shaft in the bearings. It has been found that alcohol, a common damping fluid for marine applications, has an undesirable effect on the friction associated with the bearings.

ELECTRICAL CIRCUITS AND OPERATING MOTORS, FIGS. 2 AND 4

Two-conductor cables run from each photocell to input terminals of an electric amplifying and relay means **36**, these cables being shown by broken lines in FIG. 2.

Referring to FIG. **4**, the electrical means **36** has a DC amplifier A-**31** having input and output terminals. The two conductor cable **31.1** from the forward photocell **31** is connected to the input terminals of the amplifier A-**31**, the output of which is connected to an input of a relay R-**31** having four output terminals for output lines **37, 38, 39, 41.** Lines **37** and **39** have positive polarity being marked +, lines **38** and **41** are of negative polarity being marked −, these lines are connected to reversible DC motors M-**1** and M-**2.**

The starboard and port trimming tabs **14.1, 14.2,** FIG. **1** have inner and outer edges, each tab being mounted at its inner edge for rotation about a shaft mounted on the transom, the shaft having an axis parallel to the Y axis. Rotation of a tab in one direction moves the outer edge up, and rotation in an opposite direction moves the outer edge down. These motions are effected, by obvious means not shown, by the reversible motors M-**1** and M-**2** each motor being individually controlled so as to rotate in a forward direction, in a reverse direction, or to be stopped. The motor M-**1** controls the starboard tab **14.1** and the motor M-**2** controls the port tab **14.2.** When the motor M-**1** rotates in the forward direction the outer edge of starboard tab is moved upwards, when the motor M-**1** rotates in the reverse direction the outer edge of the tab is moved downwards. The motor M-**2** similarly is connected to the port tab **14.2** with forward and reverse directions of this motor giving motions of the starboard tab as above.

Three similar amplifiers A-**32** through A-**34**, and similar relays R-**32** through R-**34**, and wiring to the motors, are provided associated with each remaining photocell namely the aft photocell **32**, the starboard photocell **33**, and the port photocell **34**.

TABLE I shows response required when a particular photocell is energized by a beam of a pulse of light from the light source **22.**

TABLE I

Response effected when a particular photocell is energized.

Photocell Energized	RESPONSE EFFECTED Port tab 14.2	Starboard tab 14.1
31 (forward)	UP, forward	UP, forward
32 (aft)	DOWN, reverse	DOWN, reverse
33 (starboard)	UP, forward	DOWN, reverse
34 (port)	DOWN, reverse	UP, forward

In a stern down position, the disc rotates to assume the FIG. 3 position energized the aft photocell **32.** When this occurs, it is required that both motors rotate in the reverse direction moving the outer edges of the flaps downwards so as to lift the stern and depress the bow. Should there be over correction, or if the vessel is in a stern up bow down attitude, the forward photocell **31** is energized, rotating both motors in the forward direction so as to correct the bow down stern up attitude.

When there is a list to starboard, the port tab **14.2** is required to move upward with the starboard tab **14.1** moving downwards, that is to say M-**1** rotates in the reverse direction and M-**2** in the forward direction. A list to port is corrected following rotation of the disc **23** to a position at which the port photocell **34** is energized so that the motor M-**1** turns in the forward direction and the motor M-**2** turns in the reverse direction.

Referring to the circuit associated with the forward photocell **31**, the relay R-**31** is a four output terminal normally-off device. When the photocell is energized current flows to the input of the amplifier A-**31**, and amplified current from the output of the amplifier energizes the relay closing it, so that the lines **37, 38, 39, 41** are energized causing both motors to rotate in the forward direction. A two conductor power line **42** from a DC source (not shown) is connected to power input terminals of the relay R-**31**, closing of which energizes the motor as aforesaid.

Circuitry associated with the photocells **32, 33,** and **34,** is as described with reference to the photocell **31.** For clarity of illustration, power line connections are shown for the relay R-**31** only, each relay being connected to the power source. Output lines from the relays R-**32** through R-**34** to the motors have polarities as shown, and are connected as shown in FIG. **4** so as to provide response according to TABLE I.

It is seen that the sensing means is responsive to continued departure of the vessel from design attitude, i.e., to list and to stern up or stern down attitude.

Transistor amplifiers are commonly used for reasons well known to those skilled in the art, power being obtained from the power supply of the vessel. Any amplifier capable of amplifying the photocell output to energize the relay can be used, the relay typically is a 100 ma device with 10 amp contacts.

It is to be noted that required HP of the electric motors depends upon mechanical advantage of the drive means connecting the motors to the tabs, and upon required speed of rotation of the tabs. A half HP motor is adequate for small vessels, particular optimum horsepower being a matter of design. Other photoelectric devices, e.g., an EMF source and a photo-conducting cell such as a selenium cell, can be substituted for a photocell.

Clearly, four light sources could be substituted for the single light source **22**, each of the four light sources being constructed and arranged to illuminate only one particular photoelectric cell. This and other multiple light source possibilities are contemplated, being within the invention.

Particular electronic means used to amplify the photoelectric output, and electro-mechanical means used to activate the trimming means, are not of themselves of importance. Any electronic and electro-mechanical means adapted to amplify the photoelectric output and to cause trimming tab motions as aforesaid can be substituted for the particular means indicated herein, and trimming means other than tabs can be used. Rather than using electric power to drive an electric motor to move the tabs the relay output can, for instance, be adapted to energize a solenoid valve of a hydraulic motor to attain equivalent results.

OPERATION

With electrical drive generally as described with reference to FIG. 4 a limit switch is provided at upper and lower limits of rotation of each tab. In FIG. 4 lines 43 and 44 are shown connected to the input line 34.1 of the amplifier A-34, the limit switches are normally open and are closed when a tab reaches an extremity of its range of motion, closing of the limit switch shorts the photocell output to ground if necessary through a suitable protective resistance not shown, so that the relay R-34 (being a normally open relay) opens, cutting off power to the motor or motors as the case might be. The lines 43 and 44 are also connected to each of the amplifier input lines 31.1–33.1 which connections are omitted for clarity of illustration.

Depending upon the size of the vessel, the size of the tabs and the speed at which they move, unless the required trim correction is small a tab will ordinarily move to a limit before correction if completed, in such case the tab will remain at that limit since input to the concerned amplifier will be shorted by the limit switch. When design attitude is attained the disc can be, at least momentarily, in a position of neutral equilibrium so as to not rotate and de-energize the related photocell. Such equilibrium is an ideal, rather than an actual, situation as there is likely to be sufficient rolling and/or pitching to cause the disc to rotate so that light rays no long impinge the photocell. In a case where the disc remains in a position energizing this photocell, over correction will result causing the disc to rotate through 180°. Hunting can in theory occur, in practice hunting has not been found to be of consequence provided the viscosity of the damping fluid is sufficiently high. Magnitude of the weight 35.2 FIG. 3 influences speed of response to the disc 23, which weight is not critical — an ounce or so at a distance of a few inches from the Z′ axis is satisfactory.

Pulse duration and/or rate are adjustable, limits hereinabove are satisfactory using a common 15 watt incandescent bulb with the specified photocell. Response of the sensing means is difficult to define in terms, but depends upon parameters such as unbalance, i.e., magnitude of the weight 35.2 hereinafter an unbalancing weight, and its distance from the Z′ axis, viscosity of the damping fluid, power of the illuminating source, its distance from the photocell, sensitivity and output of the photocell itself, and upon other considerations. Generally, pitch and roll oscillations are of materially different frequencies, and it is desirable that the motors are not energized by pitch and roll oscillations.

Optimum results are attained when the motors do not respond to pitch and roll oscillations, but only to lack of trim as discussed. Note that with e.g., a list and periodic roll oscillations additional thereto, one photocell is impinged periodically. Thus the tab moves incrementally until a limit is reached, hence an integrating effect is attained.

In fishing vessels as ordinarily used in Pacific Coast waters satisfactory results are attained using parameters within the ranges specified. Where in a particular vessel, or in particular circumstances, response is unsatisfactory, this can readily be changed by substituted a damping fluid of different viscosity, by using a light source of different power, by putting a resistance in series with the lamp source, by altering pulse repetition rate and/or flash duration, and in other obvious ways. The device will function with the light source being continuously on. It is however found that better results are attained generally, with less tendency to respond to periodic oscillations, by using a flasher. A common thermo-flasher with adjustment for flash duration and rate has been found to be satisfactory and gives a simple convenient means of adjustment.

For practical reasons, it is well to locate the sensing means near the stern of the vessel, but it can be placed elsewhere - if excessive line drop in the lines 31.1-34.1 can be avoided. The trim tabs are described as being stern mounted on the transom of the vessel. Trim tabs can be placed projecting outwards from the side of the vessel adjacent the bow or stern, or at both locations. Rather than trim tabs, equivalent results can be attained by having the motors drive pumps to transfer fuel or liquid ballast from one tank to another.

I claim:

1. An automatic trimming device for correcting trim of a moving vessel having perpendicular X and Y axes of roll and pitch respectively, the X and Y axes being horizontal when the vessel is in the design attitude, and a mutually perpendicular Z axis, the device including:

a. a sensing means responsive to a continued departure of the vessel from design attitude, the means including:

i. an unbalanced disc mounted for free rotation about a pivot axis parallel to the Z axis, the disc having an opening,

ii. forward and aft photoelectric cells in a plane normal to the Y axis, port and starboard photoelectric cells in a plane normal to the X axis, the said planes intersecting in the pivot axis, each photoelectric cell having an electrical output responsive to light rays impinging thereon,

iii. a light source with rays from the light source impinging a particular one of the said photoelectric cells when the opening is in a plane containing the particular photoelectric cell and the pivot axis,

b. trimming means adapted to correct the continued departure aforesaid,

c. means interconnecting the sensing means and the trimming means adapted to activate the trimming means to correct the departure aforesaid.

2. A trimming device as defined in claim 1, further including:

d. means to actuate the light source to produce intermittent light pulses having rate and duration parameters.

3. A device according to claim 1, in which the means interconnecting the sensing means and the trimming means includes,

d. means to amplify the output of each photoelectric cell,

e. relay means energized by each amplified output, the relay means activating the trimming means aforesaid.

4. A device according to claim 3, the trimming means including two trim tabs, and a reversible electric motor operatively connected to each trim tab, each relay being connected to each motor so as to cause each motor to rotate, according to which one of the photoelectric cells is being impinged by rays from the light source, in a direction to correct the departure aforesaid.

5. A device according to claim 4, the trim tabs having limits of motion, a limit switch at each limit of motion, the limit switch being adapted to stop the electric motor when a tab reaches a limit aforesaid.

6. A device as defined in claim 1 in which the means interconnecting the sensing means and the trimming means includes,

f. each photoelectric cell having electrical output and means to amplify the output of each photoelectric cell,

g. the amplified output of each photoelectric cell being associated with a relay means energized by amplified output, each relay means being adapted to activate the trimming means as aforesaid.

7. A devide according to claim 1 wherein the light source is on the pivot axis produced.

8. An automatic trimming device for correcting trim of a moving vessel, a sensing means responsive to continued departure of the vessel from design attitude, the vessel having mutually perpendicular X and Y axes of roll and pitch respectively, the X and Y axes being horizontal when the vessel is in the design attitude, and a mutually perpendicular Z axis; the sensing means being characterized by,

a. an unbalanced disc mounted for free rotation about a pivot axis parallel to the Z axis, the disc having an opening,

b. a photoelectric cell having a light responsive electrical output, the photoelectric cell being in a plane normal to a horizontal axis aforesaid and containing the pivot axis,

c. a light source with rays from the light source impinging the photoelectric cell when the opening is in the plane containing the photoelectric cell.

9. A sensing means as defined in claim 8, further including

d. means to actuate the light source to produce intermittent light pulses having rate and duration parameters.

10. A sensing means as defined in claim 8 in which:

e. the unbalanced disc is journalled for rotation in a chamber containing damping fluid, the damping fluid having sufficient viscosity to reduce speed of response of the disc to filter short period oscillations arising from wave motion.

11. A sensing means as defined in claim 8 in which the sensing means includes:

(i) a sealed housing having a cylindrical side wall sealed by spaced top and bottom end walls, and a transparent partition dividing the housing into an upper chamber above the partition, and a lower chamber below the partition, the top end wall mounting the photocells,

(ii) aligned pivot bearings provided in the top end wall of the housing and on the partition, the pivot bearings mounting the disc for rotation within the upper chamber.

12. A sensing means as defined in claim 11 in which a damping fluid is provided in the upper chamber to reduce speed of response of the disc to filter short period oscillations arising from wave motion.

13. A device as claimed in claim 12 in which the damping fluid is a mixture of kerosene and glycerine.

* * * * *